10/004044 ASW JAN 25 2002

F-249

PNEUMATIC APPARATUS WITH REMOVABLE VACUUM SHOE

CROSS REFERENCE TO RELATED APPLICATIONS

Reference is made to pending Application Serial Number 09/648,578 (Attorney Docket No. E-804), entitled METHOD AND APPARATUS FOR FEEDING ENVELOPES, assigned to the assignee of this application and filed on August 28, 2000.

TECHNICAL FIELD

The present invention relates to an envelope supply device and, more particularly, to an envelope feeder in an envelope insertion machine.

BACKGROUND OF THE INVENTION

In a typical envelope insertion machine for mass mailing, enclosure materials are gathered in a gathering section and moved toward an inserting station where the enclosure materials are inserted into an envelope. Envelopes are separately fed to the inserting station and each envelope is placed on a platform with its flap flipped back all the way for insertion. Before envelopes are fed to the insertion station, they are usually supplied in a stack in a supply tray. Envelopes are then separated by an envelope feeder so that only one envelope at a time is moved into the inserting station. In a high-speed insertion machine, the feeder should be able to feed single envelopes at a rate of approximately 18,000 #10 envelopes per hour. At this feeding rate, it is critical that only a single envelope at a time is picked up and delivered to the insertion station.

In the past, as in the envelope feeder disclosed in U.S. Patent No. 5,415, 068 (Marzullo), envelopes are singulated by using a belt to transport the last envelope in a stack to move downstream. If one or more envelopes move along with the last envelope, it will be stopped by a mechanical retarder which provides a friction force against the moving envelope. In the envelope feeder, as disclosed in Marzullo, the

envelopes are stacked vertically and the bottom of the stack is spring-loaded to allow envelopes to be separated from the top of the stack. This type of envelope feeder requires adjustments to be made to the envelope feeder or the envelope transport. Thus, while this type of top-separation design can eliminate some of the problems usually associated with pack pressure on units that rely on gravity to deliver the envelopes toward the separating device, envelope restocking is very inconvenient.

Thus, it is advantageous and desirable to provide an envelope feeder that can deliver individual envelopes at a high feeding rate and, at the same time, eliminate the above-mentioned problems and inconvenience.

SUMMARY OF THE INVENTION

According to the first aspect of the present invention, a vacuum shoe for use in a rotatable pneumatic apparatus for retrieving an item at a pickup point, wherein the pneumatic apparatus comprises an inner cylinder having an outer periphery with a least one cutout region formed therein, the inner cylinder further having an air passageway communicating with said at least one cutout region and with an air pressure device so as to provide a negative pressure to said at least one cutout region; and an outer cylinder concentrically mounted on the outer periphery of the inner cylinder for rotation, wherein the outer cylinder comprises at least one opening communicable with said at least one cutout region when said at least one opening is adjacent the pickup point while the outer cylinder is rotated relative to the inner cylinder. The vacuum shoe comprises:

a securing mechanism for removably mounting the vacuum shoe on an outer surface of the outer cylinder; and

at least one aperture communicable with said at least one opening, such that when said at least one opening of the outer cylinder is adjacent the pickup point, the negative pressure at the aperture causes the item to become attached to the vacuum shoe, allowing the pneumatic apparatus to move said item away from the pickup point.

According to the second aspect of the present invention, a rotatable pneumatic apparatus for retrieving an item at a pickup point. The pneumatic apparatus comprising:

an inner cylinder having an outer periphery with a least one cutout region formed therein, the inner cylinder further having an air passageway communicating with said at least one cutout region and with an air pressure device so as to provide a negative pressure to said at least one cutout region;

an outer cylinder concentrically mounted on the outer periphery of the inner cylinder for rotation, wherein the outer cylinder comprises at least one opening communicable with said at least one cutout region of the inner cylinder when said at least one opening is adjacent the pickup point while the outer cylinder is rotated relative to the inner cylinder;

a vacuum shoe positioned on an outer surface of the outer cylinder, the vacuum shoe having at least one aperture communicable with said at least one opening of the outer cylinder, such that when said at least one opening of the outer cylinder is adjacent the pickup point, the negative pressure at the aperture causes said item to become attached to the vacuum shoe, allowing the pneumatic apparatus to move said item away from the pickup point; and

a securing mechanism for removably securing the vacuum shoe to the outer cylinder, allowing the vacuum shoe to be removed from the pneumatic apparatus for maintenance or replacement.

Preferably, the inner cylinder is rotated independently of the outer cylinder such that when said at least one opening of the outer cylinder is rotated to a releasing point, said at least one cutout region of the inner cylinder becomes off-aligned with said at least one opening for reducing the negative pressure at the aperture of the vacuum shoe so as to allow said item to be released from the vacuum shoe at the releasing point.

Preferably, the outer cylinder is rotated along one direction, and the inner cylinder is rotated alternatively along the same direction and along an opposite direction in an oscillating motion such that said at least one cutout region of the inner cylinder

alternately becomes aligned with said at least one opening of the outer cylinder for providing the negative pressure at the aperture of the vacuum shoe, and becomes off-aligned with the said at least one opening of the outer cylinder for reducing the negative pressure at the aperture of the vacuum shoe.

According to the third aspect of the present invention, an envelope feeder for feeding envelopes at a pickup point, which comprises:

a deck for supporting a stack of the envelopes;

a rotatable pneumatic feeding head for retrieving one envelope at a time from the stack, wherein the feeding head comprises an inner cylinder having an outer periphery with at least one cutout region formed therein, the inner cylinder further having an air passageway communicating with said at least one cutout region and with an air pressure device so as to provide a negative pressure to said at least one cutout region; an outer cylinder concentrically mounted on the outer periphery of the inner cylinder for rotation, wherein the outer cylinder comprises at least one opening communicable with said at least one cutout region when said at least one opening is adjacent the pickup point while the outer cylinder is rotated relative to the inner cylinder; a vacuum shoe positioned on an outer surface of the outer cylinder, the vacuum shoe having at least one aperture communicable with said at least one opening of the outer cylinder, such that when said at least one opening of the outer cylinder is adjacent the pickup point, the negative pressure at the aperture causes said envelope to become attached to the vacuum shoe, allowing the pneumatic apparatus to move said envelope away from the pickup point; and a securing mechanism for removably securing the vacuum shoe to the outer cylinder, allowing the vacuum shoe to be removed from the pneumatic apparatus for maintenance or replacement, and

a rotating mechanism, operatively connected to the feeding head, for rotating the outer cylinder relative to the inner cylinder.

Preferably, the inner cylinder is rotated independently of the outer cylinder such that when said at least one opening of the outer cylinder is rotated to a releasing point,

said at least one cutout region of the inner cylinder becomes off-aligned with said at least one opening for reducing the negative pressure at the aperture of the vacuum shoe so as to allow said envelope to be released from the vacuum shoe at the releasing point.

Preferably, the outer cylinder is rotated along one direction, and the inner cylinder is rotated alternatively along the same direction and along an opposite direction in an oscillating motion such that said at least one cutout region of the inner cylinder alternately becomes aligned with said at least one opening of the outer cylinder for providing the negative pressure at the aperture of the vacuum shoe, and becomes off-aligned with the said at least one opening of the outer cylinder for reducing the negative pressure at the aperture of the vacuum shoe.

According to the present invention, the envelope feeder also comprises a strip-away plate located adjacent to the feed head for stripping away said envelope from the vacuum shoe, and a pair of take away rollers for further moving said envelope from the releasing point.

The present invention will become apparent upon reading the description taking in conjunction with Figures 1 to 5E.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an isometric view showing the envelope supply device, according to the present invention.

Figure 2 is an isometric view showing the pneumatic feeding head.

Figure 3 is a cross sectional view of the pneumatic feeding head.

Figure 4 is an exploded view showing the replaceable vacuum shoe in relation with the outer cylinder of the pneumatic feeding head.

Figure 5A is a diagrammatic representation illustrating the outer cylinder being positioned at the pickup point prior to picking up an envelope.

Figure 5B is a diagrammatic representation illustrating an envelope being attached to the feeding head by the negative pressure.

Figure 5C is a diagrammatic representation illustrating the attached envelope being moved away from the pickup point.

Figure 5D is a diagrammatic representation illustrating the attached enveloped being engaged with a nip.

Figure 5E is a diagrammatic representation illustrating the envelope being carried away by the nip while the outer cylinder is moving toward the initial position.

DETAILED DESCRIPTION

Figure 1 illustrates an isometric view of an envelope supply device **10**, which is a part of an envelope insertion machine (not shown). As shown in Figure 1, the envelope supply device **10** includes a feed tray, or main deck **12**, a pair of deck supports **14**, a pusher back paddle **16**, a lead edge deck **18** and a pneumatic feeding head **20**. The pneumatic feeding head **20** is located at one corner of the downstream end **90** of the envelope supply device **10**. Envelopes are stacked into a stack (not shown) between the pneumatic apparatus **20** and the pusher back paddle **16**. The envelope stack is constantly pushed by the pusher back paddle **16** toward the downstream end **90** so that the envelope supply device **10** will have an adequate supply of envelopes for feeding. One of the envelopes is shown in dashed lines and denoted by numeral **100**. Each envelope of the stack is vertically oriented, with one of the long edges touching the main deck surface, and one of the side edges aligned against the lead edge deck **18**, which is substantially perpendicular to the surface of the main deck **12**. The side edge that is aligned against the lead edge deck **18** is referred to as the lead edge of the envelope. It is preferred that the envelopes are stacked upside down with the crease line (top long edge) touching the deck surface, and the flap closed and facing the pusher back paddle **16**. It is also preferred that the main deck **12** is tilted at an angle α from the horizontal plane such that the long edges of the envelopes are also substantially tilted at the same angle α from the horizontal plane. The tilt angle α can range from 5 to 45 degrees, but, preferably, about 30 degrees. With the main deck **12** being tilted at an

angle, the envelopes in the stack are pulled towards the lead edge deck **18** by gravity. As such, all the envelopes are justified at the lead edge regardless of the envelope size. Thus, the tilting of the main deck substantially eliminates the requirement to adjust the envelope supply device **10** in order to accommodate envelopes of different sizes. At the downstream end **90** of the main deck **12**, a stop fence **24** is used to stop the approaching envelopes. As described later in conjunction with Figures 2 and 5A-5E, the pneumatic apparatus **20** uses a negative air pressure to pick up or retrieve the envelopes **100**, one at the time, from the envelope stack. After picking up the envelope, the pneumatic apparatus **20** is rotated toward a pair of take-away rollers **26** so that the envelope picked up by the pneumatic apparatus **20** can be moved away from the pneumatic apparatus **20** and the envelope stack. As shown, the take-away rollers **26** are mounted on a roller mount **28**. Also shown in Figure 1 is a separator plate **30**, movably mounted on the lead edge deck **18**. The separator plate **30** is used to adjust the gap between the envelope stack and the pneumatic apparatus **20**, as shown in Figures 5A-5E, to prevent more than one envelope from being taken away at a time from the envelope stack by the pneumatic apparatus **20** and the take-away rollers **26**. It is also preferred that a strip-away plate **34** is used to strip the retrieved envelope from the pneumatic apparatus **20**, as shown in Figure 5E. As shown in Figure 1, an envelope sensor **32** located on the stop fence **24** is used to alert an operator when the envelope supply is low or depleted.

Figure 2 illustrates an isometric view of pneumatic apparatus **20**. As shown, the pneumatic apparatus **20** includes a feeding head **40** which can be rotated about an axis **200** which is substantially perpendicular to the surface of the main deck **12**. The feeding head **40** comprises an outer cylinder **50** on which a vacuum shoe **42** having a row of apertures **44** is removably mounted. The apertures **44** are used to provide the suction force necessary to pick up the lead edge of an envelope **100**, as shown in Figures 5B and 5C. The suction force is produced by pumping air out of the feeding head **40** through an air conduit **82** thereby creating a vacuum or a negative air pressure at the aperture **44**. Air is pumped out by a vacuum pump in a manner known in the art.

The vacuum pump is not shown in Figure 2. When the feeding head **40** is rotated such that the apertures **44** are located near the envelope stack **102** (Figures 5A-5E), the negative air pressure at the apertures **44** draws the lead edge of the outer-most envelope **100** of the envelope stack **102** towards the vacuum shoe **42**, causing the envelope to become attached to the feeding head **40**, as shown in Figure 5B. As the feeding head **40** continues to rotate, as shown in Figures 5C and 5D, it moves the attached envelope **100** toward the take-away rollers **26** so as to allow the take-away rollers **26** to move the envelope **100** away from the pickup point **150**. The attached envelope **100** is then stripped off from the feeding head **40** by a strip-away plate **34** and the envelope is moved further away by the take-away rollers **26**. Also shown in Figure 2 are two inner rollers **38**, each of which is used to form a take-away nip with a respective take-away rollers **26**.

It is preferred, however, that the feeding head **40** also comprises an inner cylinder **60** which can be rotated independently of the outer cylinder **50**, as shown in Figures 5A through 5E. The outer cylinder **50** has a number of openings **52** communicating with the apertures **44** of the vacuum shoe **42**. The inner cylinder **60** has an outer periphery **62** surrounding an inner hollow core **80**, which communicates with the air conduit **82**. The outer periphery **62** of the inner cylinder **60** has one or more cutout sections **64**. As air is pumped out from the inner core **80** and the cutout sections **64** of the inner cylinder **60** via the air conduit **82**, a negative air pressure is provided to the apertures **44** when the cutout sections **64** of the inner cylinder **60** are aligned with the openings **52** of the outer cylinder **50**. Thus, when the inner cylinder **60** and the outer cylinder **50** are in an aligned position, the apertures **44** are operatively connected to the vacuum pump via the air conduit **82**. However, when the inner cylinder **60** and the outer cylinder **50** are completely out of alignment, the negative air pressure is not provided to the apertures **44** through the cutout sections **64**. In this respect, the inner cylinder **60** is used as an air valve, which can turn on or off the negative air pressure at the apertures **44** of the vacuum shoe **42**. Accordingly, when the inner cylinder **60** and

the outer cylinder **50** are not in the aligned position, the apertures **44** are operatively disconnected from the vacuum pump.

Also shown in Figure 3 are various movement devices: pulley **70** is used to rotate the outer cylinder **50**; pulley **72** is used to rotate the inner cylinder **60**; and pulley **74** is used to drive the inner rollers **38** and take-away rollers **26**.

As the vacuum shoe **42** is used to pick up envelopes by negative air pressure at the apertures **44** at a high rate, the envelopes can damage the shoe surface after a certain period of feeding operation. Thus, it is desirable that the vacuum shoe **42** can be removable from the feeding head **40** so the damaged shoe surface may be repaired, or a new vacuum shoe may be used to replace the damaged one. As shown in Figure 4, the vacuum shoe **42** has two mounting holes **46** and the outer cylinders have two threaded holes **56** so that the vacuum shoe **42** can be secured to the outer cylinder **50** by bolts **58**. As such, the vacuum shoe **42** can be removed from the outer cylinder **50** if so desired. As shown in Figure 4, the apertures **44** on the vacuum shoe **42** are aligned with the openings **52** of the outer cylinder **50**.

Figures 5A through 5E illustrate the principle of envelope feeding using the feeding head **40,** which has an inner cylinder **60** and an outer cylinder **50**. Because the apertures **44** and the openings **52** are always aligned as the vacuum shoe **42** is securely mounted on the outer cylinder **50** by the bolts **58**, only the apertures **44** are shown in Figures 5A-5E. For clarity, the vacuum shoe **42** and the openings **52** are not shown. When the inner cylinder **60** and the outer cylinder **50** are aligned, the cutout regions **64** in the outer periphery **62** of the inner cylinder **60** communicate with the apertures **44**.

Figure 5A shows an initial position of the outer cylinder **50** in an envelope feeding cycle. As shown, while the apertures **44** are positioned at the pickup point **150**, the cutout sections **64** of the inner cylinder **60** are not aligned with the apertures **44**. Therefore, the apertures **44** are operatively disconnected from the vacuum pump, and the feeding head **40** has no effect on the outer-most envelope **100** of the envelope stack **102**.

When the inner cylinder **60** is rotated relative to the outer cylinder **50** such that the cutout sections **62** of the inner cylinder **60** are aligned with the apertures **44**, as shown in Figure 5B, the apertures **44** are operatively connected to the vacuum pump via the inner core **80** of the inner cylinder **60**. The negative air pressure at the apertures **44** draws the lead edge of the envelope **100** towards the feeding head **40** and causes the envelope **100** to become attached to the feeding head **40**. The opposing motion of the outer cylinder **50** and the inner cylinder **60** creates a very sharp negative pressure (or vacuum burst) as cutout section **64** of the inner cylinder **60** comes into alignment with apertures **44** in a scissor-like action. As cutout section **64** and apertures **44** slide into alignment from opposing directions, the sudden vacuum burst created by the alignment has been found to be highly effective in successfully drawing the envelope **100** to the feeding head **40**.

As shown in Figure 5C, the outer cylinder **50** continues to rotate in a counter-clockwise direction, as indicated by arrow **160**, and the outer cylinder **50** brings the attached envelope **100** into contact with the take-away rollers **26**. At the same time, the inner cylinder **60** is rotated in a clockwise direction. As soon as the envelope **100** picked up by the outer cylinder **50** is taken away by the take-away rollers **26**, the negative air pressure at the openings **52** is no longer needed. The point where the envelope **100** is taken away by the take-away rollers **26** is referred to as the releasing point. Thus, it is preferred that as soon as the envelope **100** picked up by the outer cylinder **50** reaches the releasing point where the envelope **100** is taken over by the take-away rollers **26**, the outer cylinder **50** and the inner cylinder **60** are completely out of alignment so that the cutout sections **64** of the inner cylinder **60** are not in a communication position with the apertures **44**, as shown in Figure 5D. The opposing motion of outer cylinder 50 and inner cylinder 60 limits reduction in vacuum capacitance by more sharply and quickly disengaging the vacuum source from apertures **44**. The apertures **44** are now operatively disconnected from the vacuum pump. This allows the vacuum in the inner core **80**, the cutout sections **64** and the air conduit **82** to

be properly re-established. At the same time, the envelope **100** is no longer pneumatically attached to the feeding head **40** by the negative pressure from the vacuum source at the apertures **44**.

As shown in Figure 5E, the envelope **100** picked up by the feeding head **40** is stripped away from the feeding head **40** by a strip-away plate **34**, effectively releasing the envelope **100** from the feeding head **40**. As the outer cylinder **50** continues to move in the counter-clockwise direction **160**, in order to position the apertures **44** at the pickup point **150**, the inner cylinder **60** is rotated along the same direction, as indicated by arrow **164**, effectively keeping the cutout sections **62** away from the pickup point **150**. The envelope feeding cycle repeats itself as the feeding head **40** comes back to the position shown in Figure 5A.

In performing the envelope feeding cycle described herein, it is preferred that the outer cylinder **50**, inner cylinder **60**, and takeaway roller **26** be independently controllable. Such independent control allows flexibility for improving the efficiency and reliability of the feeding operation. Preferably, such independent control can be achieved by driving the components with separately controlled servo motors. For example, instead of takeaway roller **26** at a constant rate, it can run at a variable speed in order to ramp up the speed of the envelope as it is being removed from the stack, in order to perform a cleaner hand-off to a downstream drive element. Inner and outer cylinders **50** and **60** may also be electronically geared to each other for part of the feed cycle. If desired, the relative motion of the components could be adjusted to modify the vacuum profile experienced by a fed envelope so that it can be released earlier or later, as may be appropriate for different operating conditions. Also, if there is a problem with an original attempt to feed an envelope, the component controls can be programmed with a motion profile to perform a refeed within the same cycle.

In general, the surface of the vacuum shoe **42** must withstand very high speed action. At the same time, the surface must have sufficient friction to help carry the

attached envelope away from the pickup point. Accordingly, the surface finish of the vacuum shoe **42** may vary with the types, sizes and weights of the envelopes to be fed.

Thus, the present invention has been disclosed in the preferred embodiment thereof. It should be understood by those skilled in the art that the foregoing and various other changes, omissions and deviations in the form and detail thereof may be made without departing from the spirit and the scope of this invention.